(12) UK Patent Application (19) GB (11) 2 032 173 A

(21) Application No 7933570
(22) Date of filing 27 Sep 1979
(23) Claims filed 27 Sep 1979
(30) Priority data
(31) 78/40035
(32) 10 Oct 1978
(33) United Kingdom (GB)
(43) Application published 30 Apr 1980
(51) INT CL[3] H01K 1/04 3/02
(52) Domestic classification H1F 2D2A 2D6D 2D6E1 2D6E2 2D6F 2D6J 2D6M 2D6N 2D6X 2D8D 2D9 2N1 4D3
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GB 802731
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(58) Field of search
H1D
H1F
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# (54) Electric Incandescent Lamps

(57) To prevent or reduce blackening of the envelope due to evaporation of metal or carbon from the filament of an incandescent lamp, the filament is coated with a refractory, ceramic or cermet material which is stable at all temperatures at least up to the temperature attained by the filament in operation of the lamp. Suitable coating materials include refractory metal oxides such as zirconia, hafnia and thoria, refractory metal carbides, nitrides, borides and silicides, for example tantalum carbide and boron nitride, and mixtures of these materials with refractory metals which will not evaporate at the operating temperature. The coating may be deposited from suspension in a liquid, or from a vapour phase reaction mixture, or may be formed, for example, by carburisation of the surface layers of a tungsten or tantalum filament.

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SPECIFICATION
**Electric Incandescent Lamps**

This invention relates to electric incandescent lamps of the type comprising a filament formed of refractory metal or carbon enclosed within a glass envelope, and to methods of manufacturing such lamps.

It is well known that, in an incandescent lamp having a refractory metal or carbon filament, blackening of the lamp envelope tends to occur as a result of evaporation of material from the filament at the high temperature attained by the filament in operation of the lamp, and deposition of the vaporised material on the envelope wall. Tungsten, which is the metal most usually employed for forming lamp filaments, is particularly liable to undergo some evaporation under the conditions of operation of an incandescent lamp. In order to suppress this evaporation, it is customary to provide a gas filling within the envelope; however, this has the disadvantage, as compared with an evacuated envelope, that thermal loss from the filament occurs as a result of heat conduction in the gas. The proportion of heat lost from the filament in this way may be up to at least 12.5%: such heat loss will of course result in an appreciable reduction in the brightness of the light emitted by the lamp, for a given power input.

It is an object of the present invention to provide incandescent lamps incorporating improved filaments whereby the above-described disadvantages can be reduced or overcome.

According to the invention, in an electric incandescent lamp consisting essentially of a filament enclosed within a glass envelope, the filament is composed of refractory metal or carbon with a continuous, adherent surface coating consisting of a refractory ceramic or cermet material which is stable at all temperatures at least up to the temperature attained by the filament in operation of the lamp, or of a mixture of two or more such materials.

The filament may be of a standard form, consisting either of a carbon fibre or of a single, double or triple coil of fine wire composed of tungsten or of any other suitable refractory metal, for example tantalum, or refractory metal alloy. The coating may consist of any ceramic material, or mixed metal-ceramic material, which is stable, that is to say does not undergo any decomposition, fusion or evaporation, at temperatures up to at least 2400°C. Suitable coating materials include refractory metal oxides such as zirconia, hafnia and thoria, refractory metal carbides, nitrides, borides and silicides, especially tantalum carbide or boron nitride, and mixtures of these materials with refractory metals which will not evaporate at the aforesaid temperatures.

In the manufacture of the lamp, the refractory coating material may be deposited on the preformed filament from the liquid or vapour phase, the filament then being heated to cause the deposited material to form a homogeneous, adherent film covering the whole of the surface of the filament. If desired a plurality of layers of different compositions may be applied to the filament in this manner. Alternatively, a metal filament may be heated in a gaseous atmosphere which will react with the surface layers of the filament metal to form a layer of the coating material, for example the metal carbide or nitride; if desired, the composition of the coating may be varied through its thickness, by varying the composition of a gaseous mixture from which it is formed, so as to form a plurality of layers of graded composition. In another alternative method of manufacture, a carbon filament may be coated with a refractory metal and heated to cause the metal to combine with the underlying carbon to form a carbide.

The refractory ceramic or cermet coating on the filament is effective in suppressing evaporation of the filament material during operation of the lamp. Thus the presence of this coating ensures that no blackening of the lamp envelope, due to evaporation of filament material, will occur, and furthermore renders unnecessary the use of a gas filling for suppressing evaporation from the filament. The envelope may therefore be evacuated, thus preventing thermal loss from the filament in operation.

Some specific filaments for lamps in accordance with the invention, and methods of manufacturing the filaments, will now be described in the following examples.

**Example 1**

The filament of this example is composed of tungsten wire coated with zirconia. A tungsten filament of standard design, for example a coiled coil filament, is liquid coated by immersion in a solution of zirconium oxychloride in methanol, the methanol is then evaporated off by heating the filament at 100°C in vacuum and finally the filament is heated to a temperature of 600°C to decompose the zirconium oxychloride to zirconia and to form a film of deposited zirconia, of substantially uniform thickness of approximately one micron or more, over the whole of the surface of the filament.

**Example 2**

In this case a tungsten filament, suitably of coiled coil form, is provided with a coating of boron nitride. The preformed filament is heated to a temperature of 750°C while exposed to a flowing vapour mixture of boron trichloride with an excess of ammonia at a total vapour pressure of 100 to 200 $N/m^2$. The vapours react to form boron nitride, which is deposited on the filament, and the heating of the filament is continued to form a homogenous film of boron nitride of thickness exceeding one micron over the whole of the surface of the wire.

**Example 3**

The filament of this example consists of

tungsten or tantalum wire with a coating of tantalum carbide. The coating is formed on a tantalum filament by carburising the surface layers of the wire: the preformed filament, which may be of standard coiled form, is heated to 2500°C while exposed to a flowing mixture of hydrogen and benzene containing more than 50% by volume of hydrogen. In the case of a tungsten filament, a thin layer of tantalum is deposited over the surface of the filament by the Van Arkel process, that is to say by decomposing tantalum iodide or tantalum chloride vapour at a temperature of 1700—1800°C, and this layer is then carburised as in the case of a tantalum filament. If desired, the carbide surface layers may be of graded composition, the innermost layer or layers adjacent to the metallic tantalum or tungsten being composed of $Ta_2C$ and the outer layer or layers or TaC, possibly with an intermediate layer or layers of intermediate composition: this grading is achieved by varying the composition of the hydrogen-benzene mixture, the proportion of benzene being progressively increased as the carburisation proceeds.

**Example 4**

In this example a carbon filament is provided with a coating of tantalum carbide by deposition of a layer of tantalum metal on the carbon filament by the vapour deposition process described in Example 3, and carburisation of the tantalum by combination with the carbon in the surface layers of the filament. Carburisation may occur during the deposition of the tantalum, or may be promoted by heating the tantalum-coated filament to 2000°C in an inert atmosphere.

The manufacture of a lamp, incorporating a filament produced in accordance with any of the above examples, is completed by conventional procedures, the filament being supported by wires sealed into a pinched foot tube which is itself sealed into an aperture in the glass envelope, and the envelope being provided with a cap carrying contacts to which the filament support wires are connected.

**Claims**

1. An electric incandescent lamp consisting essentially of a filament enclosed within a glass envelope, wherein the filament is composed of refractory metal or carbon with a continuous, adherent surface coating consisting of a refractory ceramic or cermet material which is stable at all temperatures at least up to the temperature attained by the filament in operation of the lamp, or of a mixture of two or more such materials.

2. A lamp according to Claim 1, wherein the said coating material consists of or includes one or more refractory metal oxides.

3. A lamp according to Claim 2, wherein the said coating material consists of or includes zirconium oxide, or hafnium oxide, or thorium oxide.

4. A lamp according to Claim 1, wherein the said coating material consists of or includes one or more of the refractory metal compounds consisting of carbides, nitrides, borides and silicides.

5. A lamp according to Claim 4, wherein the said coating material consists of or includes tantalum carbide or boron nitride.

6. A lamp according to Claim 1, wherein the said coating material consists of a mixture of one or more of the materials specified in Claim 2, 3, 4 or 5 with at least one refractory metal which will not evaporate at the said temperatures.

7. A lamp according to any preceding Claim, which lamp is evacuated.

8. A method of manufacturing a lamp according to any preceding Claim, wherein the said coating material is deposited on a preformed filament from the liquid or vapour phase, and the filament is then heated to cause the deposited material to form a homogeneous, adherent film covering the whole of the surface of the filament.

9. A method according to Claim 8, wherein a plurality of layers of different compositions are applied to the filament from the liquid or vapour phase.

10. A method of manufacturing a lamp according to any of the preceding Claims 1 to 7, which lamp has a metal filament, wherein the filament is heated in a gaseous atmosphere which will react with the surface layers of the filament metal to form a layer of said coating material.

11. A method according to Claim 10, wherein the composition of the said coating is varied through its thickness, by varying the composition of the gaseous atmosphere so as to form a plurality of layers of graded composition.

12. A method of manufacturing a lamp according to Claim 1, which lamp has a carbon filament, wherein the filament is coated with a refractory metal and is heated to cause the metal to combine with the underlying carbon to form a carbide.

13. A method of manufacturing a lamp according to Claim 1, substantially as hereinbefore described in any one of the specific Examples 1, 2, 3 or 4.

14. An electric incandescent lamp manufactured by a method according to Claim 13.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1980. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.